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Multidisciplinary Coprolite Analysis

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BIGHORN CAVE

Test Excavation of a Stratified Dry Shelter
Mohave County, Arizona

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Chapter 7

MULTIDISCIPLINARY COPROLITE ANALYSIS

Karl J. Reinhard, Dennis R. Danielson, Mark Daniels, and Sergio Miranda

Coprolite analysis, as reviewed by Reinhard and Bryant (1992), contributes unique and detailed information regarding diet and parasitic disease. We present here an analysis of dietary components of coprolites from Bighorn Cave using macroscopic remains, pollen concentrations, and phytoliths. In addition, we analyzed Bighorn Cave coprolites for evidence of parasitic organisms, especially intestinal worms. Such analyses of coprolites have become important methods for reconstructing past dietary and medicinal practices. Pollen concentration and phytolith quantification techniques have recently been developed, but until this report no known attempt has been made to synthesize pollen, macroscopic, and phytolith data from a single coprolite series.

MATERIALS AND METHODS

The Specimens

We analyzed 21 coprolites, designated Samples 1–21, from Components I–III of Bighorn Cave (Table 7.1). After photographing each specimen with color and black-and-white film, we made specific observations about the shape, size, and content (as evident from the surface) of each coprolite. Based on these observations we made a preliminary determination of whether the coprolites were of human origin. We also noted evidence of insect activity, such as the presence of larvae cases and beetle and arthropod holes. The preliminary examination of the coprolites indicated that all were in the range of variation for human feces. Confirmation of fecal origin was made during the rehydration process when it was noted that bile pigments were produced by all coprolites in contact with trisodium phosphate. Sample 14, however, had an unusual green tinge to the rehydration fluid and a pronounced "musty" smell, indicating that this was not a human coprolite.

Pollen Analysis Methods

Two portions were broken from each coprolite: a 10 g piece for macrobotanical and parasite analyses, and a 2 g piece for pollen analysis. The 2 g pieces were fragmented and rehydrated for 24 hours in trisodium phosphate along with four *Lycopodium* tablets (each containing approximately 11,200 spores). After rehydration, each sample was treated for 30 minutes in 10% potassium hydroxide and then disaggregated with a magnetic stirrer. The potassium hydroxide softens plant tissue in the coprolite and the magnetic stirrer releases pollen that might otherwise be trapped in the plant remains. The samples were then screened through a 300 micrometer mesh. The fluid passing through the screen was collected in a large glass beaker and then centrifuged in 100 ml tubes. The concentrated solid microscopic remains were then transferred to 50 ml tubes for chemical extraction.

The extraction of the pollen involved several stages. The sediments were first treated with hydrochloric acid (70%) and were then rinsed with water. They were then bathed in nitric acid for 2 hours followed by a water

Table 7.1. Feces analyzed from Bighorn Cave (some specimen weights not recorded).

Sample No.	FS No.	Bag No.	Item No.	Weight	Comp.	Pollen	Phyto-lith	Macro	Parasite
1	177	1	1	31.3	III	x	x	x	x
2	345	2	1	27.9	III	x	x	x	x
3	345	3	1	19.7	III	x	x	x	x
4	345	4	1	17.8	III	x	x	x	x
5	345	5	1	19.4	III	x	x	x	x
6	345	6	1	21.3	III	x	x	x	x
7	345	7	1	16.2	III	x	x	x	x
8	266	1	2	48.7	II	x	x	x	x
9	390	1	1	59.2	I	x	x	x	x
10	321	1	1	–	III	x	x	x	x
11	321	1	2	–	III	x	x	x	x
12	321	1	4	–	III	–	x	x	–
13	321	1	5	–	III	x	x	x	x
14	279	6	1	–	III	x	x	x	x
15	382	1	1	16.7	II	x	x	x	x
16	382	4	1	26.0	II	x	x	x	x
17	229	1	1	–	II	x	x	x	x
18	229	1	5	–	II	x	–	x	x
19	177	2	1	12.2	III	x	–	x	x
20	177	4	1	19.4	III	x	–	x	x
21	177	3	1	24.7	III	x	–	x	x

Note: Number 14 is carnivore, not human.

rinse. Hydrofluoric acid (30%) was added and the tubes were placed in a boiling water bath for an hour, after which the samples were rinsed with water and then rinsed twice with glacial acetic acid preparatory to acetolysis. The acetolysis mixture of 1 part sulphuric acid and 9 parts acetic anhydride was added to each of the tubes, which were then placed in a boiling water bath for 40 minutes. Finally, the samples were washed with acetic acid and then several times with water (until the supernatant was clear).

Following the chemical extraction, the residue was washed with 95% alcohol and transferred to small vials in alcohol. Microscope slides were prepared by pipetting a drop of residue onto a slide, allowing most of the alcohol to evaporate, and mixing in a drop of glycerol. Then a cover glass was placed on top and sealed with fingernail polish. We examined the slides under 400x magnification, making a minimum count of 200 pollen grains for each slide. Pollen identification was aided by the comparative reference collection on file with the Palynology Laboratory, Texas A&M University. Oftentimes identifications could not be made with certainty; these are followed by "cf." Pollen concentrations (Table 7.2) were determined by calculating the ratio of pollen to the known number of *Lycopodium* spores per gram.

Macrobotanical and Phytolith Analysis Methods

The 10 g fragments of the coprolites were rehydrated in 10% trisodium phosphate for 48 hrs as described by Fry (1977). The samples were then agitated to disaggregate them and the slurry was poured through a 500 micrometer mesh screen. The material left on top of the screen was dried on blotter paper, and the water was collected in a beaker and centrifuged to concentrate the sediments, which were saved for parasite analysis.

The dried screen remains were then examined with a binocular dissecting microscope. The macroscopic plant constituents were identified using the comparative col-

Table 7.2. Pollen concentration values for all samples, with number of taxa found.

Sample No.	Pollen Concentration	No. of Taxa
1	14,300	21
2	16,100	22
3	29,400	24
4	72,300	14
5	26,200	21
6	26,000	27
7	114,900	8
8	150,000	13
9	29,300	18
10	36,300	18
11	224,000	8
13	53,300	21
14*	20,500	19
15	4,972,800	1
16	1,136,800	14
17	17,100	15
18	129,000	19
19	>5,000,300	2
20	2,240,000	12
21	2,340,800	10

*Non-human.

lection on file with the Ethnobotany Laboratory, Texas A&M University. In certain instances, wet mounts were made of plant tissue so the cellular and phytolith arrangements could be examined with the compound microscope.

The phytoliths were extracted following the methods of Danielson and Reinhard (1998). A small fragment from each coprolite was placed in a 500 ml beaker. We added about 5 ml of 50% hydrogen peroxide and a few crystals of potassium dichromate. The subsequent reaction destroyed all nonmineral remains and left calcium oxalate phytoliths and silica phytoliths. Identification of phytoliths was based on a reference collection of phytoliths in the University of Nebraska Microfossil Research Facility.

RESULTS

Table 7.3 gives pollen counts, Table 7.4 presents phytolith percentages, and Table 7.5 provides macroplant remains by weight. This information is summarized below by FS number according to depositional components. Much of the pollen reflects only the environmental pollen rain that in most specimens is dominated by Poaceae, low-spine Asteraceae, and *Quercus* (see Table 7.6 for common names of the identified taxa). Other coprolites, however, contain pollen types that certainly had a dietary origin. It is important to note that no cultivated plants are indicated by the pollen, phytolith, or macrobotanical remains. *Cucurbita* phytoliths occur in low frequency in Sample 9 but they are consistent with the wild species *C. foetidissima*.

Component III, Formative

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Pollen. Four separate specimens were analyzed from this provenience: Samples 1 and 19–21. Three of these have an abundance of dietary pollen but the fourth contains what is probably environmental pollen. Mustard pollen (Brassicaceae) dominates Sample 19 to the near exclusion of all other types. *Ephedra* pollen dominates Samples 20 and 21.

In areas where *Ephedra* is common, its pollen in soils varies between 8 and 45 percent (Reinhard, unpublished counts of modern ecosystems). The variation in count depends on whether the sample was collected in an area devoid of small forbs where high *Ephedra* counts occur or in areas where forbs are abundant. The amount of *Ephedra* pollen in the coprolites clearly exceeds that expected in natural pollen rain. Pollen concentration results (Table 7.2) show that Samples 19, 20, and 21 contain quantities in the millions of pollen grains per gram. Sample 19 contains such an abundance of pollen that definitive quantification was impossible other than that pollen is in excess of 5,000,000 grains per gram. Such large quantities of pollen could have been ingested with tea brewed from *Ephedra*.

Sample 1 contains about 14,300 pollen grains per gram. These grains are in a poor state of preservation. The count reflects a natural spectrum of predominantly windborne pollen types such as *Quercus*, low-spine Asteraceae, Poaceae, and Cheno-Am.

Table 7.3. Pollen counts for fecal samples from Bighorn Cave; number in parentheses is column percentage rounded to the nearest tenth. (Sample 12 contained no pollen.)

Taxa	1	2	3	4	5
Acacia	6 (2.5)	1 (0.4)	–	–	–
Acer	–	–	1 (0.5)	–	–
Acer negundo cf.	–	–	–	–	–
Alnus	–	–	–	–	–
Artemisia	1 (0.4)	1 (0.4)	5 (2.3)	1 (0.5)	3 (1.5)
Low spine	57 (24.1)	49 (21.9)	28 (12.7)	38 (19.0)	42 (20.5)
High spine	8 (3.4)	4 (1.8)	5 (2.3)	6 (3.0)	6 (2.9)
Astragalus	–	–	–	–	–
Berberidaceae	–	1 (0.4)	1 (0.5)	6 (3.0)	–
Brassicaceae	–	–	1 (0.5)	–	2 (1.0)
Carex	9 (3.8)	6 (2.7)	–	–	–
Cercidium	–	–	1 (0.5)	–	–
Cheno-Am	27 (11.4)	6 (2.7)	5 (2.3)	6 (3.0)	4 (2.0)
Ephedra sp.	–	–	–	11 (5.5)	–
Ephedra viridis cf.	7 (3)	–	–	–	5 (2.4)
Ephedra nevadensis cf.	–	–	–	–	–
Ericaceae cf.	–	–	1 (0.5)	–	–
Eriogonum cf.	5 (2.1)	3 (1.3)	3 (1.4)	–	–
Euphorbiaceae	–	–	–	–	–
Fabaceae	1 (0.4)	–	3 (1.4)	–	1 (0.5)
Fraxinus	–	–	–	–	–
Juniperus	–	7 (3.1)	2 (0.9)	–	2 (1.0)
Labiatae	–	2 (0.9)	–	–	–
Larrea	3 (1.3)	–	4 (1.8)	–	2 (1.0)
Ligulafloreae	–	–	–	–	1 (0.5)
Liliaceae	–	–	1 (0.5)	–	–
Opuntia	–	–	–	–	–
Onagraceae	–	–	–	–	–
Physalis	1 (0.4)	–	–	–	–
Pinus	10 (4.2)	12 (5.4)	3 (1.4)	13 (6.5)	1 (0.5)
Ptelea cf.	–	–	–	–	–
Poaceae	28 (11.8)	59 (26.5)	79 (35.7)	28 (14)	51 (24.9)
Polygonum cf.	1 (0.4)	–	–	–	–
Populus	1 (0.4)	1 (0.4)	10 (4.5)	–	–
Portulaca	–	–	–	–	–
Prosopis	2 (0.8)	–	–	–	1 (0.5)
Prunus cf.	–	–	1 (0.5)	–	–
Ptelia	–	–	–	–	–
Quercus	21 (8.9)	21 (9.4)	31 (14.0)	29 (14.5)	22 (10.7)
Rhamnaceae	–	2 (0.9)	2 (0.9)	–	2 (1.0)
Rosaceae	–	–	–	2 (1.0)	–
Rubiaceae	–	1 (0.4)	–	–	–
Salicaceae	–	–	–	–	–
Salix	9 (3.8)	4 (1.8)	8 (3.6)	3 (1.5)	3 (1.5)
probable *Salix*	–	–	–	–	–
Solanaceae	–	–	–	–	–
Solanum cf.	–	–	–	–	–
Sphaeralcea	–	–	–	–	–
Trifolium cf.	–	–	–	–	–
Typha latifolia	2 (0.8)	1 (0.4)	–	–	6 (2.9)
Unbelliferae	–	–	1 (0.5)	–	–
Unidentifiable	37 (15.6)	37 (16.6)	17 (7.7)	8 (4.0)	8 (3.9)
Unknown	–	–	–	1 (0.5)	1 (0.5)
Verbenaceae	–	1 (0.4)	8 (3.6)	–	1 (0.5)
Yucca	1 (0.4)	–	–	48 (24)	41 (20)

Table 7.3 (continued)

Taxa	6	7	8	9	10
Acacia	–	–	–	–	–
Acer	–	–	–	–	–
Acer negundo cf.	–	–	–	–	–
Alnus	1 (0.4)	–	–	–	–
Artemisia	4 (1.6)	–	–	1 (0.5)	6 (2.8)
Low spine	66 (27.0)	6 (3.0)	20 (10.0)	54 (27.0)	61 (28.8)
High spine	23 (9.4)	2 (1.0)	19 (9.5)	7 (3.5)	6 (2.8)
Astragalus	–	–	–	1 (0.5)	–
Berberidaceae	–	–	–	–	–
Brassicaceae	1 (0.4)	5 (2.5)	5 (2.5)	7 (3.5)	3 (1.4)
Carex	1 (0.4)	–	–	–	–
Cercidium	–	–	–	–	–
Cheno-Am	1 (0.4)	160 (80.0)	4 (2.0)	9 (4.5)	6 (2.8)
Ephedra sp.	–	–	–	1 (0.5)	–
Ephedra viridis cf.	–	–	–	–	–
Ephedra nevadensis cf.	–	–	–	4 (2.0)	4 (2.0)
Ericaceae cf.	–	–	–	–	–
Eriogonum cf.	10 (4.1)	–	–	1 (0.5)	–
Euphorbiaceae	1 (0.4)	–	–	–	1 (0.5)
Fabaceae	1 (0.4)	–	–	–	–
Fraxinus	1 (0.4)	–	–	–	–
Juniperus	1 (0.4)	–	–	1 (0.5)	–
Labiatae	–	–	–	–	–
Larrea	7 (2.9)	–	–	–	8 (3.8)
Ligulafloreae	–	–	–	–	–
Liliaceae	–	–	–	–	–
Opuntia	–	–	–	–	–
Onagraceae	–	–	–	–	–
Physalis	–	–	–	–	–
Pinus	8 (3.3)	–	1 (0.5)	11 (5.5)	10 (4.7)
Ptelea cf.	1 (0.4)	–	–	–	–
Poaceae	27 (11.1)	–	8 (4.0)	7 (3.5)	18 (8.5)
Polygonum cf.	–	–	–	–	–
Populus	7 (2.9)	8 (4.0)	1 (0.5)	–	9 (4.2)
Portulaca	1 (0.4)	–	–	–	–
Prosopis	–	–	–	–	1 (0.5)
Prunus cf.	–	–	–	–	–
Ptelia	–	–	–	–	–
Quercus	47 (19.3)	2 (1.0)	100 (50.0)	30 (15.0)	52 (24.5)
Rhamnaceae	4 (1.6)	–	–	–	–
Rosaceae	–	–	–	–	–
Rubiaceae	–	–	–	–	–
Salicaceae	–	–	–	–	–
Salix	5 (2.0)	–	1 (0.5)	29 (14.5)	3 (1.4)
probable *Salix*	–	–	–	21 (10.5)	–
Solanaceae	–	–	–	–	–
Solanum cf.	–	–	–	–	–
Sphaeralcea	1 (0.4)	–	–	–	–
Trifolium cf.	–	–	–	1 (0.5)	–
Typha latifolia	1 (0.4)	–	2 (1.0)	–	–
Unbelliferae	–	–	1 (0.5)	–	–
Unidentifiable	19 (7.9)	16 (8.0)	34 (17.0)	14 (7.0)	20 (9.4)
Unknown	–	–	4 (2.0)	1 (0.5)	1 (0.5)
Verbenaceae	1 (0.4)	1 (0.5)	–	–	2 (0.9)
Yucca	3 (1.2)	–	–	–	1 (0.5)

Table 7.3 (continued)

Taxa	11	13	14	15	16
Acacia	–	–	1 (0.5)	–	–
Acer	–	–	1 (0.5)	–	–
Acer negundo cf.	1 (0.5)	–	–	–	–
Alnus	–	–	–	–	–
Artemisia	–	–	1 (0.5)	–	1 (0.5)
Low spine	3 (1.5)	38 (19.0)	28 (14.0)	–	28 (14.0)
High spine	–	2 (1.0)	9 (4.5)	–	6 (3.0)
Astragalus	–	–	–	–	–
Berberidaceae	–	–	–	–	–
Brassicaceae	16 (8.0)	9 (4.5)	–	–	2 (1.0)
Carex	–	–	–	–	–
Cercidium	–	1 (0.5)	–	–	–
Cheno-Am	–	1 (0.5)	29 (14.5)	–	13 (6.5)
Ephedra sp.	–	2 (1)	3 (1.5)	–	1 (0.5)
Ephedra viridis cf.	–	–	–	–	–
Ephedra nevadensis cf.	–	–	–	–	–
Ericaceae cf.	–	–	–	–	–
Eriogonum cf.	–	3 (1.5)	1 (0.5)	–	–
Euphorbiaceae	–	–	–	–	–
Fabaceae	1 (0.5)	1 (0.5)	1 (0.5)	–	–
Fraxinus	–	–	–	–	–
Juniperus	2 (1.0)	–	6 (3.0)	–	–
Labiatae	–	1 (0.5)	–	–	–
Larrea	–	9 (4.5)	8 (4.0)	–	–
Ligulafloreae	–	–	1 (0.5)	–	–
Liliaceae	–	–	1 (0.5)	–	6 (3.0)
Opuntia	–	53 (26.5)	–	–	–
Onagraceae	–	–	–	–	1 (0.5)
Physalis	–	–	–	–	–
Pinus	2 (1.0)	–	26 (13.0)	–	3 (1.5)
Ptelea cf.	–	–	–	–	–
Poaceae	–	36 (18.0)	39 (18.5)	–	7 (3.5)
Polygonum cf.	–	–	–	–	–
Populus	–	–	–	–	1 (0.5)
Portulaca	–	–	–	–	–
Prosopis	–	–	–	–	–
Prunus cf.	–	–	–	–	–
Ptelia	–	–	–	–	–
Quercus	3 (1.5)	16 (8.0)	30 (15.0)	–	–
Rhamnaceae	–	3 (1.5)	–	–	–
Rosaceae	–	–	–	–	–
Rubiaceae	–	–	–	–	–
Salicaceae	–	–	–	–	–
Salix	172 (86.0)	2 (1.0)	1 (0.5)	222 (100.0)	121 (60.5)
probable *Salix*	–	–	–	–	–
Solanaceae	–	1 (0.5)	1 (0.5)	–	–
Solanum cf.	–	2 (1.0)	–	–	–
Sphaeralcea	–	–	–	–	–
Trifolium cf.	–	–	–	–	–
Typha latifolia	–	1 (0.5)	–	–	2 (1.0)
Unbelliferae	–	–	–	–	–
Unidentifiable	–	15 (7.5)	12 (6.0)	–	8 (4.0)
Unknown	–	1 (0.5)	–	–	–
Verbenaceae	–	–	–	–	–
Yucca	–	3 (1.5)	–	–	–

Table 7.3 (continued)

Taxa	17	18	19	20	21
Acacia	–	–	–	–	–
Acer	1 (0.5)	–	–	–	–
Acer negundo cf.	–	–	–	–	–
Alnus	–	–	–	–	–
Artemisia	1 (0.5)	1 (0.5)	–	–	–
Low spine	21 (9.7)	35 (16.4)	–	4 (2.0)	12 (5.7)
High spine	5 (2.3)	4 (1.9)	–	1 (0.5)	1 (0.5)
Astragalus	–	–	–	–	–
Berberidaceae	–	–	–	–	–
Brassicaceae	1 (0.5)	9 (14.2)	199 (99.5)	6 (3.0)	4 (1.9)
Carex	–	–	–	–	–
Cercidium	–	–	–	–	–
Cheno-Am	42 (19.4)	9 (4.2)	–	1 (0.5)	3 (1.4)
Ephedra sp.	3 (1.4)	4 (1.9)	–	149 (74.5)	170 (81.3)
Ephedra viridis cf.	–	4 (1.9)	–	–	–
Ephedra nevadensis cf.	–	–	–	–	–
Ericaceae cf.	–	–	–	–	–
Eriogonum cf.	–	1 (0.5)	–	–	–
Euphorbiaceae	–	–	–	–	–
Fabaceae	1 (0.5)	1 (0.5)	–	–	–
Fraxinus	–	–	–	–	–
Juniperus	–	–	–	–	–
Labiatae	–	–	–	–	–
Larrea	1 (0.5)	–	–	5 (2.5)	4 (1.9)
Ligulafloreae	–	–	–	–	2 (1.0)
Liliaceae	–	–	–	–	–
Opuntia	5 (2.3)	–	–	–	–
Onagraceae	–	1 (0.5)	–	–	–
Physalis	–	–	–	–	–
Pinus	3 (1.4)	12 (5.6)	–	1 (0.5)	–
Ptelea cf.	–	–	–	–	–
Poaceae	88 (40.7)	102 (47.9)	1 (0.5)	18 (9.0)	5 (2.4)
Polygonum cf.	–	–	–	–	–
Populus	–	4 (1.9)	–	–	–
Portulaca	–	–	–	–	–
Prosopis	–	1 (0.5)	–	–	–
Prunus cf.	–	–	–	–	–
Ptelia	–	–	–	–	–
Quercus	15 (6.9)	14 (6.6)	–	1 (0.5)	1 (0.5)
Rhamnaceae	–	1 (0.5)	–	–	–
Rosaceae	–	–	–	–	–
Rubiaceae	–	–	–	–	–
Salicaceae	–	–	–	–	–
Salix	22 (10.2)	4 (1.9)	–	1 (0.5)	–
probable *Salix*	–	–	–	–	–
Solanaceae	–	–	–	–	–
Solanum cf.	–	–	–	–	–
Sphaeralcea	–	–	–	–	–
Trifolium cf.	–	1 (0.5)	–	–	–
Typha latifolia	–	–	–	–	–
Unbelliferae	–	–	–	–	–
Unidentifiable	7 (3.2)	5 (2.3)	–	12 (6.0)	7 (3.3)
Unknown	–	–	–	–	–
Verbenaceae	–	–	–	–	–
Yucca	–	–	–	1 (0.5)	–

Table 7.4. Phytolith percentages for fecal samples from Bighorn Cave. The numbers are percentage expressions of the total count for each coprolite. The total phytoliths counted are also presented. The *Cucurbita* phytoliths are consistent with the species *Cucurbita foetidissima.*

Taxa	1	2	3	4	5	6	7	8	9	10
Agavaceae	55	68.5	77.5	1	–	25	0.9	43	15	50
Cactaceae	14	0.3	4	50	60	26.5	1	–	15	–
Cheno-Am	6	0.7	–	4	37	34	5	–	6	–
Chloridoid	–	–	0.7	–	–	–	–	2	0.4	–
Festucoid	–	5	2	2	–	2	–	10	5	50
Panicoid	–	0.3	0.7	0.9	–	0.8	–	0.4	0.8	–
Other grass	–	–	–	–	–	–	–	0.7	–	–
Fabaceae	25	25	15	42	3	12	93	43	69	–
Cucurbita	–	–	–	–	–	–	–	–	9	–
Total count	275	288	281	224	229	240	226	268	225	10

Table 7.4, continued

Taxa	11	12	13	14	15	16	17
Agavaceae	98	88	6	6	2.8	22	34
Cactaceae	2	–	28	30	43	51	44
Cheno-Am	–	0.5	29	9	34	23	20
Chloridoid	–	1	–	–	–	–	–
Festucoid	–	4	0.4	2	3	3	0.4
Panicoid	–	6	–	0.7	12	0.4	1
Other grass	–	–	–	–	–	–	–
Fabaceae	–	–	36	52	5	–	–
Cucurbita	–	–	–	–	–	–	–
Total count	49	209	238	286	264	225	280

The poor preservation suggests that the pollen types were in the environment for a long time prior to human consumption; these grains may have been consumed with drinking water.

Macro and Phytolith. Sample 1 contains small amounts of seed. One seed appears to be of the genus *Asclepias*. The others are mustard seeds similar in morphology to *Cenchris*. Charcoal is present in very small amounts. The vast majority of the macrofossil remains consist of short screwbean mesquite fibers arranged in tiny concentric circles. Most often the circular fibers occur separately, but in some instances the fibers are held in place with a thin, rough cuticle. Spiral-shaped arrangements of the fiber, resembling tendrils, are also present. These fibers originated from the consumption of screwbean mesquite, thickets of which grow along the washes of the Black Mountains. The phytoliths show that other plants were also eaten. Agavaceae accounts for 55 percent of the phytoliths and Cactaceae and Fabaceae account for 14 and 25 percent respectively. Therefore, three sources of fiber are indicated by the phytoliths.

Sample 19 contains small bone fragments. As in most other Bighorn Cave human coprolites, the bone fragments are very small and include fragments of trabecular bone, which suggests that the bone was ground for consumption. The majority of the macroscopic remains from this coprolite consist of *Opuntia* epidermis and fiber. Druse crystals are also present, sometimes still in place inside of epidermal fragments. Also present is a *Quercus* leaf and a thorn.

Table 7.5. Macroscopic remains for the Bighorn Cave fecal specimens by weight in grams. Components weighing less than 0.01 grams are indicated by "t".

Macroscopic Remains	1	2	3	4	5	6	7	8	9	10	11
Prosopis	3.21	6.72	5.67	0.84	–	–	6.89	–	–	–	t
Opuntia	t	t	0.12	t	6.46	5.71	–	–	t	0.04	0.07
Other fiber	t	t	0.15	0.11	t	–	–	t	1.13	5.36	2.44
Unidentifiable debris	–	–	–	–	–	–	–	5.87	–	–	3.35
Wood or bark	–	–	–	–	t	0.03	–	t	–	–	–
Stem	–	–	–	–	–	–	–	–	–	–	–
Bone	t	–	t	–	–	–	–	–	t	0.60	–
Charcoal	0.1	t	–	–	t	t	t	t	0.12	t	–
Sand	0.97	t	t	t	t	t	–	t	1.61	–	t
Brassiceae seed	–	–	–	–	–	–	t	–	–	–	–
Juniperus seed	–	–	–	–	–	–	–	–	–	–	–
Poaceae seed	–	t	–	–	–	–	–	–	–	–	–
Cucurbitaceae seed	–	–	–	–	–	–	–	–	–	–	–
Chenopodium seed	–	t	–	–	–	–	–	–	–	–	–
Insect fragments	t	–	–	–	–	–	–	t	t	–	–
Insect larvae	–	–	–	–	–	–	t	–	–	–	–
Charred seed testa	t	–	–	–	–	–	–	–	–	–	–
Leaf fragment	–	–	–	–	–	–	t	t	t	–	–
Unidentifiable cuticle	–	–	–	–	–	–	–	t	–	–	0.10
Unidentifiable plant residue	–	–	–	–	–	–	–	–	2.22	–	–
Resin	–	–	–	–	–	–	–	–	–	–	–

Table 7.5 continued

Macroscopic Remains	12	13	14	15	16	17	18	19	20	21
Prosopis	–	6.63	–	7.16	t	1.04	–	2.79	0.01	0.01
Opuntia	t	t	–	–	t	t	–	–	–	–
Other fiber	2.35	t	–	–	–	t	–	–	–	–
Unidentifiable debris	3.53	–	–	–	2.66	–	–	–	5.38	5.90
Wood or bark	–	–	–	–	–	–	–	–	–	–
Stem	–	t	–	–	–	t	–	t	–	–
Bone	0.44	0.24	2.0	–	–	0.24	–	–	1.21	0.68
Charcoal	t	t	–	t	0.05	t	–	t	t	t
Sand	t	t	–	t	0.16	t	–	t	–	–
Brassiceae seed	–	t	–	–	–	t	–	–	–	–
Juniperus seed	–	–	–	–	–	–	–	–	–	–
Poaceae seed	–	–	–	–	–	–	–	–	–	–
Cucurbitaceae seed	–	–	–	–	2.14	–	–	–	–	–
Chenopodium seed	–	–	–	–	–	–	–	–	–	–
Insect fragments	–	–	–	–	–	–	–	–	–	–
Insect larvae	–	–	–	–	–	t	–	–	–	–
Charred seed testa	–	t	–	–	–	t	–	–	–	–
Leaf fragment	–	t	–	–	–	t	–	–	–	–
Unidentifiable cuticle	–	t	–	–	–	–	–	–	–	–
Unidentifiable plant residue	–	–	–	–	–	–	–	–	–	–
Resin	–	–	–	–	–	–	–	–	–	–

Table 7.6. Scientific and common names of pollen taxa recovered from coprolites at Bighorn Cave.

Scientific Name	Common Name
Acacia	Acacia
Acer	Maple
Alnus	Alder
Artemisia	Sage
Asteraceae	Composite family
Astragalus	Vetch
Berberidaceae	Barberry family
Brassicaceae	Mustard family
Carex	Sedge
Cercidium	Palo verde
Cheno-Am	Goosefoot family and amaranth (pigweed) family
Ephedra sp.	Mormon tea, species unknown
Ericaceae	Heather family
Eriogonum	Wild buckwheat
Euphorbiaceae	Spurge family
Fabaceae	Legume family
Fraxinus	Ash
High spine	Asteraceae subgroup that includes sunflower
Juniperus	Juniper
Labiatae	Mint family
Larrea	Creosote
Ligulafloreae	Asteraceae subgroup that includes dandelion
Liliaceae	Lily family
Low spine	Asteraceae subgroup that includes ragweed
Opuntia	Prickly pear
Onagraceae	Evening primrose family
Physalis	Ground cherry
Pinus	Pine
Poaceae	Grass family
Polygonum	Smartweed
Populus	Cottonwood
Portulaca	Portulaca
Prosopis	Mesquite
Ptelia	Hop tree
Quercus	Oak
Rhamnaceae	Buckthorn family
Rubiaceae	Madder family
Salix	Willow
Solanaceae	Potato family
Sphaeralcea	Mallow
Trifolium type	Clover-like legume
Typha latifolia	Cattail
Unbelliferae	Carrot family
Unidentifiable	Pollen grains too degraded to identify certainly
Unknown	Pollen grain morphology could not be identified
Verbenaceae	Vervain family
Yucca	Yucca

Sample 20 also contains small bone fragments, apparently from fish. Also present are remains of *Allium* (onion) bulbs. The majority of the coprolite consists of a fine brown substance of unknown origin. A wood fragment is also present. Sample 21 contains bone similar to Sample 19. Some fiber is present, as is the cuticle of an unidentified plant.

FS 279

The single coprolite from this provenience is from a nonhuman carnivore. Before rehydration, it was composed of a hard, dark crust surrounding a core of bone and air. It contains about 20,500 pollen grains per gram. The dominant types are windborne. The pollen content of this coprolite no doubt mirrors the environmental pollen rain present at the time of defecation.

The macroscopic part of Sample 14 consists entirely of bone and hair. The bones are those of a small rodent. The plant dietary component of this coprolite is represented in the phytolith count: Fabaceae is most common, probably from mesquite, followed by Cactaceae, Cheno-Am, Agavaceae, and various grasses.

FS 321

Pollen. Three coprolites (10, 11, and 13) were processed from this provenience. An additional coprolite (12) was analyzed, but processing and reprocessing recovered no pollen. The pollen analysis from 10 did not demonstrate any clear examples of dietary types. However, Sample 11 is dominated by willow (*Salix*) and 13 contains a relatively large percentage of *Opuntia* pollen. *Salix* is a windborne type that is especially common in spring. However, it is improbable that *Salix* would normally make up 86 percent of the pollen rain. This undoubtedly reflects dietary use of the plant. *Opuntia* rarely accounts for more than 2 percent of the normal pollen rain, even in a prickly pear patch (Reinhard, unpublished pollen counts of modern ecological zones). The more than 25 percent *Opuntia* pollen in Sample 13 is clearly a result of dietary usage of the plant. In Sample 10, 36,300 pollen grains per gram are present, and 53,300 grains per gram are present in 13. A relatively high pollen concentration value of 224,000 grains per gram was obtained from Sample 11.

Macro and Phytolith. Sample 10 consists of small bone fragments similar to those found in 19. Also present is a small amount of *Opuntia* epidermis. Most of the coprolite consists of fiber. Very few phytoliths were found; half are from a cactus and half are from a festucoid grass. Samples 11 and 12 consist solely of fiber, perhaps *Agave*. Samples 11 and 12 both have abundant phytoliths from an Agavaceae plant, consistent with *Agave*. Sample 13 yielded mostly mustard seed. The seeds are very abundant and seem to have been eaten as a "cake." Many seeds are broken and may have been prepared by crushing or grinding. The seed morphology is very close to that of *Descurainia*. Also present in this sample are the circular fibers from screwbean mesquite described for Sample 1. Cactaceae, Cheno-Am, and Fabaceae phytoliths are very common in this sample, along with small amounts of Agavaceae.

FS 345

Pollen. Six coprolites were analyzed from FS 345 (Samples 2–7). Two of these (2 and 6) were different from the other four in having poorly preserved pollen similar to Sample 1 of FS 177. Both of these samples probably reflect the natural pollen rain. The relatively high Poaceae count of Sample 3 suggests that Poaceae pollen was introduced into the intestine through dietary means, but this cannot be said with certainty. *Yucca* pollen in 5 and 6 clearly indicates a dietary use of this plant because *Yucca* pollen is not normally present in pollen rain in such high percentages. The dominance of Cheno-Am pollen in Sample 7 probably has a dietary origin; although Cheno-Am is a windblown type, its percentage in Sample 7 exceeds the natural pollen rain of Cheno-Am that might be incidentally ingested.

Macro and Phytolith. Sample 2 contains an abundance of screwbean mesquite circular fibers. Also present are *Chenopodium* seeds and possibly *Panicum* seed. These seeds appear unground and were probably eaten whole. Sample 3 contains what appear to be well-masticated insect fragments. Fiber dominates the macrofossil remains, but *Sporobolus* seeds are also present in small numbers. Samples 2 and 3 are both dominated by Agavaceae phytoliths with a strong showing of Fabaceae phytoliths. Sample 4 consists mostly of coarse fiber. *Allium* tissue is also present, as is a possible *Yucca* seed. The phytolith analysis shows that large amounts of cactus and Fabaceae were eaten. Sample 5 consists mostly of *Opuntia* epidermis and some fiber. The phytoliths from Sample 5 are dominated by Cactaceae, with some Cheno-Am. Sample 6 consists mostly of *Opuntia* epidermis and some fiber. Sample 7 consists primarily of circular screwbean mesquite fibers, along with a few *Sporobolus* seeds that appear to be parched. Nearly all the phytoliths are from Fabaceae.

Component II, Terminal Archaic

FS 229

Pollen. Both of the samples from FS 229 have high percentages of Poaceae pollen. Although this is a windborne type and consequently is easily ingested by inhalation and drinking, as well as eating, the high percentages of Samples 17 and 18 indicate that it was a dietary type in these incidences. The average Poaceae percentage for all human coprolites from Bighorn Cave is 13.8 percent. Sample 17 contains 41 percent and 18 contains 48 percent. This strongly suggests that grass in these instances is dietary. Another dietary type, Brassicaceae, is represented by a 14 percent rate in Sample 18. This is a high percentage for an insect-pollinated species, and probably indicates a dietary origin. Both 17 and 18 contain large amounts of fine charcoal in the pollen preparations. This is similar to coprolites from Dust Devil Cave that we have examined in which high grass pollen percentages occurred with large amounts of charcoal. We suspect that parching grass seeds or inflorescences accounts for the co-occurrence. Pollen concentration indicates that 17,000 and 129,000 grains per gram are present in 17 and 18, respectively (Table 7.2).

Macro and Phytolith. In Samples 17 and 18, nearly all of the rehydrated material passed through the screen. A juniper nut and a bit of fine fiber are present in Sample 17. Only sand and gravel were present after 18 was processed. The gravel and sand were probably incorporated in the coprolite from contact with the cave substrate. Considering the pollen analyses, it is likely that ground grass seed, perhaps parched, constituted the meals represented in Samples 17 and 18. However, the phytoliths show that at least three other plants were eaten: Agavaceae, Cactaceae, and Cheno-Am.

FS 266

Pollen. The one coprolite from this provenience contained about 150,000 pollen grains per gram. The pollen counts are dominated by *Quercus* (50%). The relatively high percentage of unidentifiable pollen (17%) constitutes spindled or crushed grains that are probably *Quercus*. In scrubland dominated by *Quercus*, up to 45 percent of the natural pollen rain is derived from it (Reinhard, unpublished pollen counts of modern ecological zones). The average *Quercus* percentage for all human coprolites from Bighorn Cave is 10.1 percent. The high percentage in Sample 8 could be due to dietary reasons. However, *Quercus* is a prolific pollen producer, and is wind pollinated. Therefore, it is possible that the high percentage is due to incidental consumption with food or drink.

Macro and Phytolith. Sample 8 consists of a finely ground, dark brown meal. It is not possible to determine the source of the meal from macroscopic or palynogical examination. However, the phytoliths show that Agavaceae composed a large part of the meal. Also, various grasses, including Chlorodoid, Festucoid, and Panicoid were eaten. Also, Fabaceae phytoliths are abundant, probably from mesquite.

FS 382

Pollen. Samples 15 and 16 have very high pollen grain per gram values (4,972,800 and 1,136,000 respectively). A large amount of fine charcoal is present in 16. Both samples contain large percentages of *Salix* pollen that certainly indicate consumption of this plant. In 15, the large number of *Salix* pollen grains exceeds all other types.

Macro and Phytolith. Sample 15 is dominated by screwbean mesquite fibers. Minor components are *Descurainia* cf. seeds and what looks like a fragment of snakeskin. Cactus, Cheno-Am, and grass dominate the phytolith count from this sample. Sample 16 consists of smashed acorn hulls in a fine brown matrix. Agavaceae, Cactaceae, and Cheno-Am phytoliths are abundant in this sample.

Component I, Late Archaic

FS 390

The single sample from this provenience contains badly degraded pollen that might reflect consumption of *Salix*. Of the pollen grains counted, almost 15 percent are *Salix*. Degraded grains that are probably *Salix* constitute another 10 percent. Pollen concentration indicates 29,300 grains per gram.

The macro remains of this specimen consist solely of coarse fiber. Agavaceae, Cactaceae, and Fabaceae phytoliths are abundant.

PARASITOLOGICAL ANALYSIS

The centrifuged sediments left over from macrobotanical separation were transferred into vials and sedimented gravitationally in acetic formalin alcohol. Previous work with this technique has demonstrated that parasite eggs and larvae settle out in the upper level of the sediment (Reinhard 1985a). Microscopic preparation requires only a few drops of sediment. Drops of sediment from the upper layers of the debris are placed on a microscope slide. When the acetic formalin alcohol has nearly evaporated, a small drop of glycerol is added to the preparation. The sediment and glycerol are thoroughly mixed with an applicator stick and a cover glass is placed on top. The cover glass is sealed with fingernail polish and the preparation is scanned under 200x for helminth eggs. For quantification, one *Lycopodium* tablet is added to each gram of coprolite. This allows for egg per gram (epg) calculation of parasite infections by calculating the known ratio of spores to eggs or larvae.

No definite parasite infections are apparent in the 1 carnivore and 20 human coprolites. However, what are possibly tapeworm eggs of the family Taeniidae, or fungal spores resembling taeniid eggs, were found in Samples 2 (640 epg) and 10 (200 epg). The objects are spherical, averaging 32 micrometers in diameter, and exhibit a thick, radially striated wall. These observations are consistent with the form of taeniid eggs. However, no hooklets were visible on the interiors of the possible eggs. Because the hooklets are not present, it is possible that the objects are fungal and not parasitic.

Free-living, nonparasitic nematode larvae are present in Samples 9 and 16. These are the only coprophagous organisms found in the analysis. Free-living mites and other arthropods that are often found in the microscopic fraction of coprolites from the Southwest are absent in the Bighorn Cave coprolites.

DISCUSSION

The data resulting from the analyses of three different fecal constituents are combined in Tables 7.7 and 7.8. The pollen analysis demonstrates that the prehistoric inhabitants of the cave lived in a xeric environment but utilized nearby water sources. The presence of *Acer*, *Salix*, *Populus*, *Typha*, and *Carex* pollen demonstrates the use of wet environments. The analysis shows that at least one of these genera, *Salix*, was of dietary use. An overall dry environment is indicated by *Ephedra*, *Yucca*, *Artemisia*, *Prosopis*, *Acacia*, *Larrea*, *Juniperus*, *Sphaeralcea*, and *Opuntia*. Of these plants, *Yucca*, *Opuntia*, and *Ephedra* were eaten. *Prosopis* was also consumed but the evidence for this comes from phytoliths and macroplant remains. Other dietary plants that could be from either environment include mustard, grass, and Cheno-Am.

Table 7.7. Summary of dietary remains per coprolite.

Sample 1: Phytolith data indicate consumption of plants in the Agavaceae, Cactaceae, and Fabaceae. The most likely genera consumed were *Agave*, *Opuntia*, and *Prosopis*. Phytoliths consistent with *Chenopodium* or *Amaranthus* were also found. The main macrofloral dietary component was mesquite. A small animal was eaten.

Sample 2: Phytolith data indicate consumption of plants in the Agavaceae and Fabaceae. The most likely genera consumed were *Agave* and *Prosopis*. Grass phytoliths were also present. The main macrofloral dietary component was mesquite. Small amounts of goosefoot seed were also eaten.

Sample 3: Phytolith data indicate consumption of plants in the Agavaceae and Fabaceae. The most likely genera consumed were *Agave* and *Prosopis*. Grass phytoliths and some cactus phytoliths were also present. Mesquite pods, prickly pear pads, and course fiber were the main macrofloral dietary components of this sample. A small animal was eaten.

Sample 4: Pollen data indicate that yucca buds or flowers were eaten. Phytolith data indicate consumption of plants in the Cactaceae and Fabaceae. The most likely genera consumed were *Opuntia* and *Prosopis*. Small amounts of Agavaceae and grass phytoliths are also present. Mesquite pods and course fiber were the main macrofloral dietary components of this sample.

Sample 5: Pollen data indicate that yucca buds or flowers were eaten. Phytolith data indicate that Cactaceae and Cheno-Am were eaten. The most likely genera eaten were *Opuntia* and *Chenopodium-Amaranthus*. Prickly pear pads were the main macrofloral component.

Sample 6: Phytolith data indicate consumption of plants in the Agavaceae, Cactaceae, Cheno-Am, and Fabaceae. The most likely genera consumed were *Agave*, *Opuntia*, *Prosopis,* and *Chenopodium-Amaranthus.*

Sample 7: Pollen data indicate that buds, flowers, or greens of species of pigweed or goosefoot were eaten. Phytoliths show that Fabaceae was consumed, most likely *Prosopis*. Small numbers of Agavaceae, Cactaceae, and Cheno-Am phytoliths were also present. The main macrofloral dietary component was mesquite.

Sample 8: Phytolith data indicate consumption of plants in the Agavaceae and Fabaceae. The most likely genera consumed were *Agave* and *Prosopis*. Phytoliths indicate that grass was also eaten. There was no identifiable macroscopic component.

Sample 9: Pollen data indicate that willow was eaten. Phytolith data indicate that Fabacaeae, most probably *Prosopis,* was eaten. Smaller amounts of Agavaceae, Cactaceae, Cheno-Am, and grass were consumed as indicated by phytoliths. This was the one specimen with *Cucurbita* phytoliths, which were consistent with the wild gourd *C. foetidissima*. Fiber and unidentifiable plant residue make up the macrofloral dietary component. A small animal was eaten.

Sample 10: Small numbers of phytoliths were present from Agavaceae and grass. Course fiber and prickly pear pads make up the macrofloral dietary component. A small animal was eaten.

Sample 11: Pollen data indicate that willow was eaten. Phytoliths show that Agavaceae, probably Agave, was eaten. Some cactus was also eaten as indicated by phytoliths. Course fiber and some prickly pear pad make up the macrofloral dietary component.

Sample 12: Phytoliths show that Agavaceae, probably *Agave*, was eaten. Some grass and Cheno-Am was also eaten as shown by phytoliths. Course fiber and some prickly pear pad make up the macrofloral dietary component. A small animal was eaten.

Sample 13: Pollen data indicate that prickly pear buds or flowers were eaten. Phytolith data indicate consumption of plants in the Cactaceae, Cheno-Am, and Fabaceae families. The most likely genera consumed were *Opuntia*, *Prosopis*, and *Chenopodium-Amaranthus*. Lesser amounts of Agavaceae were consumed, as shown by phytoliths. Mesquite pods are the main macrofloral dietary component. A small animal was eaten.

Sample 15: Pollen data indicate that willow was eaten. Phytolith data indicate consumption of plants in the Cactaceae and Cheno-Am families. The most likely genera consumed were *Opuntia* and *Chenopodium-Amaranthus*. Lesser amounts of Agavaceae and Fabaceae were consumed, as shown by phytoliths. Mesquite pods are the main macrofloral dietary component.

Sample 16: Pollen data indicate that willow was eaten. Phytolith data indicate consumption of plants in the Agavaceae, Cactaceae, and Cheno-Am families. Genera most likely consumed were *Agave*, *Opuntia*, and *Chenopodium-Amaranthus*. The macrofloral dietary component comprises wild squash seeds.

Table 7.7 (continued)

Sample 17: Pollen data suggest that grass was eaten. Phytolith data indicate consumption of plants in the Agavaceae, Cactaceae, and Cheno-Am families. Genera most likely consumed were *Agave*, *Opuntia*, and *Chenopodium-Amaranthus*. Mesquite dominates the macrofloral remains although there are traces of prickly pear pad and traces of leaf, stem, and course fiber. A small animal was eaten.

Sample 18: Pollen data strongly suggest that grass was eaten. No phytolith analysis for this sample. No macrofloral remains were recovered.

Sample 19: Pollen data indicate that buds, flowers, or greens of species of mustard were eaten. No phytolith analysis for this sample. Mesquite pods dominate the macrofloral remains.

Sample 20: Pollen data indicate that Mormon tea was consumed. No phytolith analysis for this sample. The macrofloral component is composed of unidentifiable plant residue with some mesquite pod. A small animal was eaten.

Sample 21: Pollen data indicate that Mormon tea was consumed. No phytolith analysis for this sample. The macrofloral component is composed of unidentifiable plant residue with some mesquite pod. A small animal was eaten.

Table 7.8. Best determination of food components by time period.

Component I, Late Archaic

Sample 9: Willow catkins or foliage. Mesquite pods. Baked agave and prickly pear pads. Greens from grass and possibly from goosefoot and/or amaranth. A small animal.

Component II, Terminal Archaic

Sample 8: Mequite pods and baked agave. Grass greens.

Sample 15: Willow catkins or foliage (beverage). Baked prickly pear pads. Mesquite pods. Baked agave. Greens from pigweed or goosefoot.

Sample 16: Willow catkins or foliage (beverage). Baked agave and prickly pear pads. Mesquite pods. Greens from pigweed or goosefoot. Wild squash seeds.

Sample 17: Baked agave and baked prickly pear pads. Mesquite pods. Greens from pigweed or goosefoot. Grass greens. A small animal.

Sample 18: Possibly grass.

Component III, Formative

Sample 1: Mesquite pods. Baked agave and prickly pear pads. Possibly goosefoot or pigweed greens. A small animal.

Sample 2: Goosefoot seed. Mesquite pods. Baked agave. Grass greens.

Sample 3: Mesquite pods. Baked agave and prickly pear pads. Greens from grass. A small animal.

Sample 4: Yucca buds or flowers. Mesquite pods. Baked prickly pear pads and agave.

Sample 5: Yucca buds or flowers. Prickly pear pads. Possibly goosefoot or pigweed greens.

Sample 6: Baked agave and prickly pear. Mesquite pods. Greens from goosefoot or pigweed.

Sample 7: Mesquite pods, baked agave, and prickly pear stems. Greens from goosefoot or pigweed.

Sample 10: Grass greens. Baked agave and prickly pear pads. A small animal.

Sample 11: Willow catkins or foliage. Baked yucca. Baked prickly pear pads.

Sample 12: Baked yucca, baked prickly pear pads. Greens from grass and possible pigweed or goosefoot. A small animal.

Sample 13: Prickly pear buds or flowers. Mesquite pods and baked prickly pear pads. Possible goosefoot or amaranth greens. Some baked yucca and a small animal.

Sample 19: Mustard greens. Mesquite pods.

Sample 20: Mormon tea (beverage). Mesquite pods. A small animal.

Sample 21: Mormon tea (beverage). Mesquite pods. A small animal.

High pollen percentages most likely result from consumption of flowers, fruits, or possibly seeds. With regard to *Salix*, it is probable that the catkins of the tree were eaten or brewed in tea. The same is true of *Ephedra*. Russell (1975) noted that the Pimas ate the baked fruits of *Yucca*. He has also noted that the Pimas ate the fruits of prickly pear. The florettes and seeds of several species of grass were consumed prehistorically. At Dust Devil Cave, Utah, *Sporobolus* was most commonly eaten (Reinhard 1985; Van Ness 1986). Cheno-Am pollen was probably introduced by the consumption of flowers. Castetter has noted that *Chenopodium* flowers were eaten by the Yumas (1935). The possibility that *Quercus* was eaten has been raised; relative to this question, Russell has noted that the Pimas traded acorns from the Papagos, hulled them, and ground them into meal.

Low percentages of *Typha* pollen are present in several feces. In all likelihood, these grains were probably consumed with drinking water. However, Castetter and Bell (1951) have noted that *Typha* pollen was a favorite food for the Yuma, Maricopa, and Mojave Indians. There is a remote possibility that the *Typha* pollen is of dietary origin. Many Lovelock Cave coprolites are composed almost entirely of *Typha* pollen (Heizer and Napton 1969).

Although dietary usage has been assumed until this point, it must be noted that some of the plants noted above have medicinal value. According to Russell, the Pimas ate the raw flowers of *Yucca* as a purgative (1975). He also noted the use of *Ephedra* among the Pima as a cure for syphilis. Perhaps most important is the use of *Salix* to relieve pain (Vogel 1973). The use of "willow tea" was a widespread medicine among prehistoric peoples. Usually the tea is described as being brewed from willow bark or from the leaves of the plant. The introduction of willow pollen into willow tea could occur quite easily if catkins were fortuitously included with foliage in the brewing of tea. Willow contains salicin which is a pain reliever similar to aspirin. It is a simple acid that can be absorbed through the stomach. Eight of the 19 human coprolites examined in this study contain pollen of plants that are potentially medicinal (Samples 9, 11, 15, 16, 20, and 21 stand out).

Seasonality is indicated by the presence of *Quercus* pollen in most coprolites and by the presence of *Salix* in some. These plants produce pollen in early spring, suggesting that the cave was used at this time.

Five coprolites contain many pollen taxa, none of which have clear dietary origin. The pollen in all of these coprolites is extremely degraded. The pollen taxa reflect the natural pollen rain one would expect in the Black Mountains. Because these represent a complete ecological spectrum, and the preservation is so poor, these grains were likely consumed with drinking water.

The Bighorn Cave coprolites are interesting palynologically because of the number of taxa present, which could allow for environmental reconstruction if botanical data were provided along with soil samples from the locality of the cave. The soil samples could be processed palynologically to serve as a comparative base for past climate reconstruction. Bighorn Cave pollen is also interesting from the perspective of paleopharmacology—the possibility that medicines are reflected in the diet is fascinating.

COMPARISONS

Comparative analyses are available from Danger and Hogup Caves, both in Utah (Fry 1977), Lovelock Cave in Nevada (Heizer and Napton 1969), Dust Devil Cave in Utah (Reinhard 1985; Reinhard et al. 1985; Van Ness 1986), and Hinds Cave in Texas (Williams-Dean 1978; Reinhard in progress). The diets of various Southwest hunter-gatherer groups were quite variable. People at Hinds Cave depended largely on *Opuntia* seeds, *Allium* bulbs, *Opuntia* pads, *Sporobolus* seed, and walnuts. Nearly all of the 120 coprolites from that cave examined macroscopically contained bone (Williams-Dean 1978; Reinhard in progress). In Dust Devil Cave on the Colorado Plateau, Archaic people depended largely on *Opuntia* pads, *Chenopodium* seed, and *Sporobolus* seed. About 68 percent of the coprolites from Dust Devil Cave contained

bone (Reinhard 1985; Reinhard et al. 1985; Van Ness 1986). Coprolites from Danger and Hogup Caves show dependence on *Allenrolfea* seed, composite seed, and *Opuntia*. Bone was common in these coprolites as well (Fry 1977). The diet reflected in Lovelock Cave coprolites shows an adaptation to an aquatic ecosystem with consumption of fish, *Typha*, and bullrush.

The macroscopic remains from Bighorn Cave show a population that was dependent on a variety of foods. Dietary mainstays were prickly pear pads, mesquite, and coarse fiber, probably derived from *Agave* leaves. However, other plants were also important contributions to the diet, including mustard seed, chenopod seed, juniper seed, and grass seed. Whether acorns were consumed remains to be demonstrated. Bone was not very common in the coprolites (4 of 20 human coprolites contained bone); perhaps this represents a reduced consumption of meat at Bighorn Cave in comparison to other hunter-gatherer caves.

It is interesting that there is not much variation in the main diet constituents between the depositional components at Bighorn Cave (Table 7.8). Mesquite, probable *Agave*, and prickly pear were the main foods in all times. Willow, goosefoot, or pigweed greens and small animals were consumed in all components. Grass phytoliths were found in the coprolites that contain small animal bones; this suggests that these phytoliths might have been eaten by the animals and therefore grass may not have been an intentional part of the human diet. Wild squash seeds were eaten during Component II times (terminal Archaic); this dietary aspect is unique to that period. Several more constituents were present in Component III (Formative), such as goosefoot seed, mustard greens, flowers or buds of prickly pear, flowers or buds of yucca, and Mormon tea. The evident greater diversity in Component III is likely a result of having analyzed more feces from this component (15 compared to 4 for Component II and 1 for Component I). Increased sample sizes are needed for Components II and especially I before trends among the components could have behavioral meaning.

PARASITE DISCUSSION

Coprolites from several Archaic, hunter-gatherer caves have been examined parasitologically in the Great Basin (Fry 1977; Heizer and Napton 1969), from the Colorado Plateau (Reinhard et al. 1985), and from the trans-Pecos of Texas (Reinhard in progress). These serve as a comparative base for the parasitological analysis of Bighorn Cave coprolites.

Parasitological examination of hunter-gatherer coprolites rarely reveals parasitism. The examination of coprolites from Lovelock Cave in Nevada revealed only free-living nematode larvae and one possible fluke infection (Heizer and Napton 1969). The examination of 100 coprolites from Dust Devil Cave in Utah revealed no parasite infections (Reinhard et al. 1985) nor did the analysis of 20 coprolites from Hinds Cave in Texas (Reinhard in progress). Only in the analyses of coprolites from Danger and Hogup Caves in Utah were parasites found. These included pinworm, thorny-headed worm, taeniid tapeworms, and head lice (Fry 1977). The lack of parasites in the Bighorn Cave coprolites is consistent with most hunter-gatherer caves. One concludes that parasitic disease was infrequent among southwestern hunter-gatherers.

Several aspects of the lives of hunter-gatherers served to limit parasitism (Reinhard 1985a). In general, hunter-gatherer populations are dilute and intergroup contact is infrequent. Usually, fecal contamination of food is limited and thus the spread of parasite diseases is limited. One main way by which hunter-gatherers became infected with parasites was by the consumption of incompletely cooked meats and insects. This was probably the source of infection for the Hogup Cave and Danger Cave populations.

Some protozoal and bacterial pathogens are transmitted by the same conditions as parasitic worms, so it is safe to conclude that disease transferred by fecal contamination in general was limited among the Bighorn

Cave inhabitants. The diversity of foods and the presence of possible medicinal plants show that the people were well adjusted to their environment.

SUMMARY OF RECOVERED QUIDS AND FECES

Phil R. Geib

This chapter concerns human and other animal waste recovered from Bighorn Cave. The emphasis and key portion of this chapter was the previous detailed analysis of the micro- and macroscopic plant remains within human feces. Here I present a general summary of all consumption waste in the collections. Quids are included here because this seemed the most logical place—they are after all byproducts of eating, but are processed by the mouth and not the digestive system.

Table 7.9 gives a summary of the waste remains recovered from the test excavations of Bighorn Cave. The table rows are organized by the components and unassigned proveniences of Locus A, as well as Locus B, with all remains from that area treated as one group. The table gives three measures of abundance for each row: a count of FS numbers that contain each type of waste, an actual count of individual items (except for rodent and sheep or deer feces), and the total weight.

Quids

The test excavations at Bighorn Cave recovered 382 quids totaling 560.6 g, which are listed by tentative identification in Table 7.10. A moderate number of the quids exhibit distinct teeth marks (Figure 7.1). Most quids are between 3 and 6 cm in length and 1.5–2.5 cm in diameter. Many are well consolidated and the individual fibers in them are extensively crushed. Nearly all of the quids appear to consist of fibers of agave or perhaps yucca. Agave seems the most likely given the other evidence found at the site for consumption of this plant, along with the abundant ethnographic documentation of agave consumption. Consumption of yucca leaves is unlikely (rather foul tasting) and the snarled fiber masses that result from processing yucca leaves for string production are easily distinguished from chewed quids. Yucca leaves and fibers might be chewed as part of the fiber extraction process, but this should not result in the types of remains included here as quids. In agave consumption much of the cooked leaves are swallowed, but some of the more fibrous and less flavorful portions might be chewed and then expectorated.

The "Other" column includes quids of unidentifiable material, one of a chewed legume pod (perhaps mesquite), and several of probable cactus. One of the latter contains roots that appear similar to the hedgehog cactus roots observed in the plant collections (see Chapter 8). There are also quids of unknown materials, several of which were identical; other types of cactus are possible candidates. Ultimately a detailed study of the quids will provide additional information about subsistence and perhaps medicinal practices of the Bighorn Cave occupants.

The quids with meaningful provenience occur disproportionately in Component III (174 of 212 or 82% by weight). Ground moisture in some of the layers of Component I might have decomposed a portion of its quids, but differential preservation cannot be a factor with the other components, the layers of which were essentially unaffected by moisture. It could be that there was more

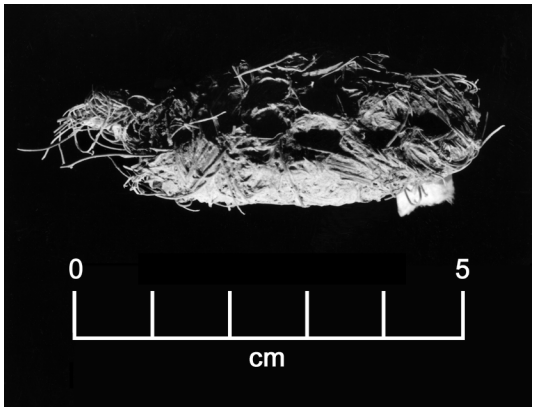

Figure 7.1. Quid with obvious teeth marks from Bighorn Cave.

Table 7.9. Summary of human and animal waste from Bighorn Cave (FS = count of proveniences).

	Quids			Animal Feces			Human Feces		
Component/Locus	FS	n	wt (g)	FS	n	wt (g)	FS	n	wt (g)
Locus A									
Component IV	5	19	26.3	0	0	0.0	3	8	39.9
Component III?	1	3	3.4	0	0	0.0	1	2	7.4
Component III	31	174	267.7	6	9	(46.1)	20	131	(476.2)
Component II–III	0	0	0.0	1	1	1.0	1	54	180.2
Component II?	0	0	0.0	0	0	0.0	1	13	65.8
Component II	7	13	14.3	3	5	11.3	10	51	(284.9)
Component I	2	3	1.9	2	5	1.2	10	38	(159.1)
Unassigned	19	119	178.4	1	1	7.6	11	21	276.4
Locus B	12	51	68.6	3	3	34.2	5	6	58.8
Total	77	382	560.6	16	24	(101.4)	62	324	(1548.7)

Numbers in parentheses slightly less than true total because of unavailable weights for seven analyzed feces.

Table 7.10. Preliminary identification of quids recovered from Bighorn Cave.

	Agave/Yucca		Other		Total	
Component/Locus	n	wt (g)	n	wt (g)	n	wt (g)
Locus A						
Component IV	18	24.9	1	1.4	19	26.3
Component III?	3	3.4	0	0.0	3	3.4
Component III	159	259.7	15	8.0	174	267.7
Component II	10	11.2	3	3.1	13	14.3
Component I	3	1.9	0	0.0	3	1.9
Unassigned	112	172.1	7	6.3	119	178.4
Locus B	51	68.6	0	0.0	51	68.6
Total	356	541.8	26	18.8	382	560.6

intensive exploitation of agave during the formation of the Component III layers; there is some supporting evidence for this in the plant remains for the site, because agave leaves were most abundant in Component III as well. One consideration though is that 47 percent of the quids (or 61% by weight) came from a single provenience of Component III—Layer 3b of S1E0. Thus it could be that our test units merely sampled a location of agave consumption for Component III but not the other components.

Feces

Excavations recovered both human and animal feces from the site, with far more of the former saved than the latter. The field crew generally collected all items that looked potentially like human feces and any carnivore feces, although the latter were few (n = 5). Ungulate droppings were quite common to most layers, with some interfaces between strata appearing to contain concentrations of such feces. Excavators collected just a few of these specimens for the primary purpose of radiocarbon dating. Table 7.11 lists the counts and weights of animal feces by general type using the same format as Table 7.9. The two collections of rodent feces, both of which came from the burned packrat middens of Locus B (upper grotto), are bulk samples consisting of many uncounted individual pellets. Several of the sheep or deer fecal collections are also of this bulk

Table 7.11. Identification of animal feces recovered from Bighorn Cave. Bulk samples of rodent and sheep or deer feces are not individually counted.

	Carnivore		Sheep/Deer		Rabbit		Rodent	
Component/Locus	n	wt (g)	n	wt (g)	n	wt (g)	n	wt (g)
Locus A								
Component III	2	(19.8)	7	26.3	–	—	–	—
Component II–III	1	1.0	–	—	–	—	–	—
Component II	–	—	4	11.2	1	0.1	–	—
Component I	–	—	5	1.2	–	—	–	—
Unassigned	1	7.6	–	—	–	—	–	—
Locus B	1	3.9	–	—	–	—	2	30.3
Total	5	(82.3)	16	38.7	1	0.1	2	30.3

Numbers in parentheses less than true total because of unavailable weight for analyzed carnivore feces.

nature—one from Component II consisting of 10.4 g (93% of the total for this component) and three from Component III (6.7, 6.9, and 11.6 g). With an approximate average pellet weight of 0.3 g, the count of individual sheep or deer feces in each of these bulk samples can be estimated, ranging from about 22 for the smallest collection to 40 for the largest. Sediment samples collected for flotation analysis doubtless contain examples of animal feces that would provide a fairly representative collection of the types and frequencies at the site. Layer interfaces that appeared to have higher than average concentrations of sheep or deer feces would be underrepresented, because few if any float samples were collected at layer contacts.

Human feces were counted individually, even the small fragments, so the 324 specimens listed in Table 7.9 are the total number collected. These range in size from small fragments weighing just 0.4 g to one truly large specimen at 112.8 g. There were several whole or nearly whole specimens, but most were portions of various size. Some had been squished into the underlying sediment when fresh, thereby adding on rock, sediment, charcoal, and vegetation to varying extents. Most of these extraneous adhesions were removed during the inventory phase; thus weights reflect essentially pure fecal material. Some of the human feces are heavily filled with fibers and appear to reflect a diet that consisted largely of agave. Other feces, however, seem to consist mostly of seeds and other remains. The fecal analysis reported previously provides a detailed account of the remains within 1 carnivore and 20 human feces.

Table 7.9 lists 54 feces from a single provenience as Component II–III. All of these came from the second arbitrary excavation level of the test unit at the dripline (S1E8). Many of these were point provenienced in three dimensions within the unit and there is no doubt that they originated from layers belonging to either Component II or III. More specific assignment will require direct dating, something that might eventually be quite practical and worthwhile given the relative rarity of prehistoric human feces.

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